US Army Corps of Engineers Washington, DC 20314-1000

Engineer Manual No. 1110-2-1204

10 July 1989

Engineering and Design ENVIRONMENTAL ENGINEERING FOR COASTAL SHORE PROTECTION

Table of Contents

		Subject	Paragraph	<u>Page</u>
CHAPTER	1.	INTRODUCTION		
		Purpose Applicability Scope References Appendices Glossary	1-1 1-2 1-3 1-4 1-5 1-6	1-1 1-1 1-1 1-1 1-2 1-3
CHAPTER	2.	OVERVIEW OF COASTAL SHORE PROTECTION PROJECTS		
		Classification Alternatives Considerations	2-1 2-2 2-3	2-1 2-1 2-1
CHAPTER	3.	ENVIRONMENTAL RESOURCES		
		Environmental Requirements Environmental Resource Categories Physical Water Quality Biological Recreational Aesthetic Cultural	3-1 3-2 3-3 3-4 3-5 3-6 3-7 3-8	3-1 3-4 3-5 3-6 3-8 3-9 3-11
CHAPTER	4.	PROTECTIVE BEACHES AND DUNES		
		Protective Beaches Dunes	4-1 4-2	4-1 4-15
CHAPTER	5.	HUMAN-MADE STRUCTURES		
		Bulkheads, Seawalls, and Revetments Jetties and Breakwaters Groins	5-1 5-2 5-3	5-1 5-9 5-25

	Subject	Paragraph	Page
CHAPTER 6.	NONSTRUCTURAL ALTERNATIVES		
	Salt Marshes Seagrasses	6-1 6-2	6-1 6-7
CHAPTER 7.	ENVIRONMENTAL MONITORING		
	Monitoring Programs Data Collection Habitat Assessment Data Analysis, Interpretation, and Presentation	7-1 7-2 7-3 7-4	7-1 7-3 7-16 7-23
CHAPTER 8.	MITIGATION DECISION ANALYSIS		
	Policy Definitions Key Concepts for Mitigation Examples	8-1 8-2 8-3 8-4	-
APPENDIX A	BIBLIOGRAPHY		A-1
APPENDIX B	MODELS		B-1
APPENDIX C	ENVIRONMENTAL PROTECTION STATUTES AND OTHER ENVIRONMENTAL REQUIREMENTS		C-l
APPENDIX D	ESTUARINE/MARINE SPECIES PROFILES		D-1
GLOSSARY		GLOSSA	RY-l

LIST OF TABLES

Table		Page
2-1 2-2 3-1 5-1	Classification of Coastal Engineering Solutions Classification of Coastal Engineering Considerations Recreational Activities and Facilities Environmental Design Considerations for Revetments,	2-2 2-3 3-10 5-10
7-1	Seawalls, and Bulkheads Sediment Sampling Equipment	7-9
7-2 B-1	An Example of a BRAT Data Tabulation Froude Criteria Scaling Relationships for physical	7-22
	Coastal Models	B-16
	LIST OF FIGURES	
Figure		Page
4-1	Visual definition of terms describing a typical beach profile	4-2
4-2	Beach nourishment operation, Mayport, Florida (courtesy of US Army Engineer District, Jacksonville)	4-3
4-3	Schematic diagram of storm wave attack on beach and dune	4-4
4-4	Reef fauna near outer edge of second reef off Golden Beach, Florida (Courtenay et al. 1980)	4-10
4-5	Nesting sea turtle	4-11
4-6	Recreational use of Delray Beach, Florida	4-12
4-7	Dunes under wave attack, Cape Cod, Massachusetts	
	(courtesy of Stephen P. Leatherman)	4-20
4-8	Dunes erosion during severe storm, Cape Cod,	
	Massachusetts ((courtesy of Stephen P. Leatherman)	4-20
4-9	Dissipative surf conditions during storm, Outer Banks,	
	North Carolina	4-22
4-10	Vegetation landward (left on photo) of artificially	
	stabilized dune, Padre Island, Texas (courtesy	
	of Bill E. Dahl)	4-25
4-11	Salt marshes landward of barrier island system,	
	Murrels Inlet, South Carolina	4-26
4-12	Linear shaped, planted dune system, Outer Banks,	
	North Carolina (courtesy of R. P. Savage)	4-28
5-1	Steel sheet pile bulkhead	5-2
5-2	Concrete curved-face seawall	5-4
5-3	Quarrystone revetment	5-5
5-4	Concrete combination stepped- and curved-face	
	seawall with public access points	5-8
5-5	Quadripod and rubble-mound breakwater	5-13
5-6	Sand bypassing, Murrells Inlet, South Carolina	5-14

LIST OF FIGURES (Continued)

Figure		Page
5-7	Erosion and accretion patterns in association	5-18
5-8	with detached and attached breakwaters	2-19
5-8	Breakwater protecting recreational harbor, Santa Barbara, California	5-23
5-9	Rubble-mound groin	5-27
5-10	General shoreline changes associated with single	3 27
5 10	or multiple groins	5-29
5-11	Irregular beach formed by cellular steel	3 2
0	sheet-pile groin	5-32
6-1	Oldest reported salt marsh planting in the	
	United States	6-2
6-2	Aesthetic comparison of nonstructural (salt marsh	
	planting) and structural (revetment) measures	6-8
6-3	Cost comparison of alternative erosion control	
	measures (after Knutson and Woodhouse 1983)	6-9
6-4	Typical seagrass and generalized method of making	
	transplant unit	6-11
6-5	Sediment capture in seagrass meadow	6-12
7-1	Three possible distribution patterns	7-5
7-2	Cumulative means calculated for a random and a	
	cluster distribution	7-6
7-3	Core sampling of sandy-bottom stations	7-11
7-4	Diver using transect line in the surf	7-12
7-5	Quadrat sampling of epibiota at reef stations	7-12
7-6	Example of a mechanistic Habitat Suitability	7-17
7 7	Index model	/-1/
7-7	Suitability index curve for substrate type for	
	juvenile Atlantic croakers Habitat Suitability Index model (Diaz and Onuf 1985)	7-18
7-8	Benthic resources assessment technique (BRAT)	7-20
7-0	penente resources assessment recinitare (prei)	, 20